Message

From: Kraft, Andrew [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=4A94A4F199B247778ABB02285A51B927-KRAFT, ANDREW]
Sent: 10/23/2013 6:19:14 PM
To: Whalan, John [Whalan.John@epa.gov]
Subject: RE: I thought you might be interested in some of the following references (from my search update), or not

I was actually thinking *you* might be interested in a few, John---- for example, there is one on exhaled breath. I will probably not be using most of these, but I will definitely let you know if I need any of those I identified to include in the neuro section (I think there are 3 new inhalation studies; 2 in animals and 1 in humans).

Andrew

From: Whalan, John
Sent: Wednesday, October 23, 2013 12:55 PM
To: Kraft, Andrew
Subject: RE: I thought you might be interested in some of the following references (from my search update), or not

Andrew,

This is quite a few studies! Let me know which ones you want to consider further and I will evaluate their exposure quality.

John

From: Kraft, Andrew
Sent: Wednesday, October 23, 2013 12:53 PM
To: Glenn, Barbara; Bateson, Thomas; Cooper, Glinda; Whalan, John; Vulimiri, Suryanarayana
Subject: I thought you might be interested in some of the following references (from my search update), or not

Cheah, NP, JLA Pennings, et al[2013[In vitro effects of aldehydes present in tobacco smoke on gene expression in human lung alveolar epithelial cells[Tobacco smoke consists of thousands of harmful components. A major class of chemicals found in tobacco smoke is formed by aldehydes, in particular formaldehyde, acetaldehyde and acrolein. The present study investigates the gene expression changes in human lung alveolar epithelial cells upon exposure to formaldehyde, acrolein and acetaldehyde at sub-cytotoxic levels. We exposed A549 cells in vitro to aldehydes and non-aldehyde chemicals (nicotine, hydroquinone and 2,5-dimethylfuran) present in tobacco smoke and used microarrays to obtain a global view of the transcriptomic responses. We compared responses of the individual aldehydes with that of the non-aldehydes. We also studied the response of the aldehydes when present in a mixture at relative concentrations as present in cigarette smoke. Formaldehyde gave the strongest response; a total of 66 genes were more than 1.5-fold differentially expressed mostly involved in apoptosis and DNA damage related processes, followed by acetaldehyde (57 genes), hydroquinone (55 genes) and nicotine (8 genes). For acrolein and the mixture only one gene was upregulated involved in oxidative stress. No gene expression effect was found for exposure to 2,5-dimethylfuran. Overall, aldehyde responses are primarily indicative for genotoxicity and oxidative stress. These two toxicity mechanisms are linked to respiratory diseases such as cancer and COPD, respectively. The present findings could be important in providing further understanding of the role of aldehydes emitted from cigarette smoke in the onset of pulmonary diseases.

Darouiche, MH, A Masmoudi, et al[2012[Contact dermatitis in south Tunisia: Patch test results (European standard series)[

Hosgood, HD, III, L Zhang, et al[2013[Occupational exposure to formaldehyde and alterations in lymphocyte subsets[BACKGROUND: Formaldehyde is used in many occupational settings, most notably in manufacturing, health care, and embalming. Formaldehyde has been classified as a human carcinogen, but its mechanism of action remains uncertain.

METHODS: We carried out a cross-sectional study of 43 formaldehyde-exposed workers and 51 unexposed age and sex-matched controls in Guangdong, China to study formaldehyde's early biologic effects. To follow up our previous report that the total lymphocyte count was decreased in formaldehyde-exposed workers compared with controls, we evaluated each major lymphocyte subset (i.e., CD4(+) T cells, CD8(+) T cells, natural killer [NK] cells, and B cells) and T cell lymphocyte subset (CD4(+) naïve and memory T cells, CD8(+) naïve and memory T cells, and regulatory T cells). Linear regression of each subset was used to test for differences between exposed workers and controls, adjusting for potential confounders.

RESULTS: Total NK cell and T cell counts were about 24% (P = 0.037) and 16% (P = 0.0042) lower, respectively, among exposed workers. Among certain T cell subsets, decreased counts among exposed workers were observed for CD8(+) T cells (P = 0.026), CD8(+) effector memory T cells (P = 0.018), and regulatory T cells (CD4(+) FoxP3(+) : P = 0.04; CD25(+) FoxP3(+) : P = 0.008).

CONCLUSIONS: Formaldehyde-exposed workers experienced decreased counts of NK cells, regulatory T cells, and CD8(+) effector memory T cells; however, due to the small sample size; these findings need to be confirmed in larger studies.

Katsnelson, BA, TD Degtyareva, et al[2013[Attenuation of subchronic formaldehyde inhalation toxicity with oral administration of glutamate, glycine and methionine[Inhalation exposure of outbred female white rats (initial age about 4 months) to formaldehyde vapours (12.8 0.69 mg/m(3)) 4h per day, 5

days per week during 10 weeks induced statistically significant changes in some indices characterizing differential WBC count, functional status of the central nervous system and liver, redox and porphyrin metabolisms, bone marrow micronuclei count as well as free amino acid spectrum of the blood serum. The development of intoxication was accompanied by increased urinary excretion of formaldehyde, formic acid and methanol. Daily oral administration of glutamate (150-180 mg), glycine (12 mg) and methionine (50mg) in combination rendered all of the formaldehyde's toxic effects reduced. This administration also caused a significant increase in the ratio between the rates of excretion of formic acid and non-metabolized formaldehyde. This shift supposedly reflects activation of oxidative detoxifying biotransformation of formaldehyde. Taking into consideration that the combination of amino acids used in this study proved innocuous in protectively effective doses, the administration in this combination may be recommended to humans exposed to high levels of formaldehyde in workplace or ambient air.

Kim, J, M Jeong, iS, et al[2013[Aggravation of atopic dermatitis-like symptoms by consecutive low concentration of formaldehyde exposure in NC/Nga mice[Formaldehyde (FA) has been known to be associated with development of asthma (AS) and atopic dermatitis (AD). In this study, we investigated whether FA inhalation would affect the provocation or exacerbation of AD-like symptoms. Atopic-prone NC/Nga mice were exposed to low (0.2ppm) and high (1.0ppm) concentration of FA by inhalation. Combined exposure to low concentration of FA inhalation and topical house dust mite (HDM) stimulation significantly upregulated HDM-induced total plasma IgE and IgG2a production, Th1-, Th2-, Th17-related cytokine as well as COX-2 mRNA expressions in the skin. Interestingly, independent FA inhalation, especially at low concentration (0.2ppm), increased the skin mRNA expressions of IL-13, IL-17E/IL-25 and COX-2, even though it failed to induce AD-like skin inflammation. In conclusion, we suggest that increased skin mRNA expressions of IL-13, IL-25/IL-17E and COX-2 by independent low concentration of FA exposure might be a key factor to exacerbate HDM-mediated AD-like skin inflammation.

Kleinnijenhuis, AJ, YC Staal, et al[2013[The determination of exogenous formaldehyde in blood of rats during and after inhalation exposure[Formaldehyde (FA) is suspected of being associated with the development of leukemia. An inhalation experiment with FA was performed in rats to study whether FA can enter the blood and could thus cause systemic toxicity in remote tissues such as the bone marrow. Therefore, a sophisticated analytical method was developed to detect blood concentrations of FA during and after single 6-h exposure by inhalation. In order to differentiate between exogenous and endogenous FA the rats were exposed to stable isotope ((13)C) labeled FA by inhalation. During and after exposure of the rats to (13)C-FA their blood was analyzed to determine the ratio between labeled and natural FA in blood and the total blood concentration of FA. With respect to sensitivity, with the applied method exogenous (13)C-FA could have been detected in blood at a concentration approximately 1.5% of the endogenous FA blood concentration. Exogenous (13)C-FA was not detectable in the blood of rats either during or up to 30 min after the exposure. It was concluded that the inhalation of (13)C-FA at 10 ppm for 6h did not result in an increase of the total FA concentration in blood.

Kuehner, S, M Schlaier, et al[2012[Analysis of leukemia-specific aneuploidies in cultured myeloid progenitor cells in the absence and presence of formaldehyde exposure[A recently published human study suggested that exposure to formaldehyde (FA) at the workplace might induce leukemia-specific aneuploidies (monosomy 7 and trisomy 8) in cultured myeloid progenitor cells. Despite its preliminary character, this study was considered by the International Agency for Research on Cancer to be a potential mechanistic explanation for the induction of leukemia by FA. To further evaluate the reliability of these findings, chromosome preparations from cultured myeloid progenitor cells (obtained from blood samples of five healthy subjects) were analyzed by fluorescence in situ hybridization (FISH) for spontaneously occurring numerical aberrations after cultivation for 9 days. FISH analysis with probes for chromosomes 6, 7, and 8 revealed that the baseline frequency of aneuploid metaphases is similar and rather low for all three chromosomes tested. More monosomies than trisomies were measured. We also exposed myeloid progenitor cells during the whole cultivation period to FA and determined the frequency of aneuploidies after 9 days of cultivation. The results clearly indicate that FA did not induce aneuploidy under these experimental conditions. In contrast, aneuploidy was induced under these conditions by the known aneugen vincristine. Myeloid progenitor cells from healthy subjects were not particularly sensitive toward the cytotoxic action of FA. Colony forming ability in the presence of FA was not reduced to a higher degree than in cultured cell lines (A549; V79). Our results do not support the assumption of a specific effect of FA on myeloid progenitor cells as a potential mechanism for the induction of leukemia.

Lacourt, A, E Cardis, et al[2013[INTEROCC case-control study: lack of association between glioma tumors and occupational exposure to selected combustion products, dusts and other chemical agents[BACKGROUND: The aim was to investigate possible associations between glioma (an aggressive type of brain cancer) and occupational exposure to selected agents: combustion products (diesel and gasoline exhaust emissions, benzo(a)pyrene), dusts (animal dust, asbestos, crystalline silica, wood dust) and some other chemical agents (formaldehyde, oil mist, sulphur dioxide).

METHODS: The INTEROCC study included cases diagnosed with glioma during 2000-2004 in sub-regions of seven countries. Population controls, selected from various sampling frames in different centers, were frequency or individually matched to cases by sex, age and center. Face-to-face interviews with the subject or a proxy respondent were conducted by trained interviewers. Detailed information was collected on socio-economic and lifestyle characteristics, medical history and work history. Occupational exposure to the 10 selected agents was assessed by a job exposure matrix (JEM) which provides estimates of the probability and level of exposure for different occupations. Using a 25% probability of exposure in a given occupation in the JEM as the threshold for considering a worker exposed, the lifetime prevalence of exposure varied from about 1% to about 15% for the different agents. Associations between glioma and each of the 10 agents were estimated by conditional logistic regression, and using three separate exposure indices: i) ever vs. never; ii) lifetime cumulative exposure; iii) total duration of exposure.

RESULTS: The study sample consisted of 1,800 glioma cases and 5,160 controls. Most odds ratio estimates were close to the null value. None of the ten agents displayed a significantly increased odds ratio nor any indication of dose-response relationships with cumulative exposure or with duration of exposure.

CONCLUSION: Thus, there was no evidence that these exposures influence risk of glioma.

Larsen, ST, P Wolkoff, et al[2013[Acute airway effects of airborne formaldehyde in sensitized and non-sensitized mice housed in a dry or humid environment[We investigated the role of air humidity and allergic sensitization on the acute airway response to inhaled formaldehyde (FA) vapor. Mice were sensitized to the immunogen ovalbumin (OVA) by three intraperitoneal injections followed by two aerosol challenges, giving rise to allergic airway inflammation. Control mice were sham sensitized by saline injections and challenged by saline aerosols. Once sensitized, the mice were housed at high (85-89%) or low (<10%) relative humidity, respectively for 48h prior to a 60-min exposure to either 0.4, 1.8 or about 5ppm FA. Before, during and after exposure, breathing parameters were monitored. These included the specific markers of nose and lung irritations as well as the expiratory flow rate, the latter being a marker of airflow limitation. The sensory irritation response in the upper airways was not affected by allergic inflammation or changes in humidity. At high relative humidity, the OVA-sensitized mice had a decreased expiratory airflow rate compared to the saline control mice after exposure to approximately 5ppm FA. This is in accordance with the observations that asthmatics are more sensitive than non-asthmatics to higher concentrations of airway irritants including FA. In the dry environment, the opposite trend was seen; here, the saline control mice had a significantly decreased expiratory airflow rate compared to OVA-sensitized mice when exposed to 1.8 and 4ppm FA. We speculate that increased mucus production in the OVA-sensitized mice has increased the "scrubber effect" in the nose, consequently protecting the conducting and lower airways.

Morfeld, P[2012[Diesel exhaust in miners study: how to understand the findings?[The Diesel Exhaust in Miners Study (DEMS) is an outstanding epidemiological project on the association between occupational diesel exhaust exposures, measured as long-term respirable elemental carbon (REC) estimates, and lung cancer mortality in a large cohort of US miners. Two articles published recently (Attfield et al. (J Natl Cancer Inst Epub, 2012), Silverman et al. (J Natl Cancer Inst Epub, 2012)) dsescribed the epidemiological findings. These papers are expected to have considerable impact on the evaluation of the carcinogenic potential of diesel exhaust and, furthermore, on occupational and environmental limit value discussions related to diesel motor emissions and particle exposures. DEMS found remarkable exposure-response relationships between REC exposure estimates and lung cancer mortality - conditional on a pronounced effect of surface vs. underground work on lung cancer risk. If this risk factor is ignored the estimated REC-lung cancer association is attenuated substantially. The authors relied on this risk factor in their main analyses. However, this factor "surface/underground work" remained unexplained. The factor lead the authors to introduce unusual cross-product terms of location and smoking in adjustment procedures and even caused the authors to hypothesize that high REC exposures are protective against lung cancer excess risks due to smoking. To understand the reliability of these conclusions, we should ask basic questions about the data collection process in DEMS: Did the mortality follow-up procedures suffer from errors like those that affected the NCI formaldehyde cohort study? Are the REC and/or smoking data reliable, and are these data collected/constructed in such a way that the procedures allow valid comparisons between surface and underground workers? Without clarifying the issues raised in this Commentary the Diesel Exhaust in Miners Study remains to be difficult to interpret.

Mueller, JU, T Bruckner, et al[2013[Exposure study to examine chemosensory effects of formaldehyde on hyposensitive and hypersensitive males[OBJECTIVE: Main objective of this study was to examine the chemosensory effects of formaldehyde on hyposensitive and hypersensitive males at concentrations relevant to the workplace. Attention focused on objective effects on and subjective symptoms of the mucous membranes of the eyes, the nose, the upper respiratory tract and olfactory function. METHODS: Forty-one male volunteers were exposed for 5days (4h per day) in a randomised schedule to the control condition (0ppm) and to formaldehyde concentrations of 0.5 and 0.7ppm and to 0.3ppm with peak exposures of 0.6ppm, and to 0.4ppm with peak exposures of 0.8ppm, respectively. Peak exposures were carried out four times a day over a 15-min period of time. Subjective pain perception induced by nasal application of carbon dioxide served as indicator for sensitivity to sensory nasal irritation. The following parameters were examined before and after exposure: subjective rating of symptoms and complaints (Swedish Performance Evaluation System), conjunctival redness, eye-blinking frequency, self-reported tear film break-up time and nasal flow rates. In addition, the influence of personality factors on the volunteer's subjective scoring was examined (Positive And Negative Affect Schedule). RESULTS: Formaldehyde exposures to 0.7ppm for 4h and to 0.4ppm for 4h with peaks of 0.8ppm for 15min caused no significant sensory irritation of the measured conjunctival and nasal parameters. No differences between hypo- and hypersensitive subjects were seen. Nevertheless, statistically significant differences were noted for olfactory symptoms, especially for the 'perception of impure air'. These subjective complaints were more pronounced in hypersensitive subjects. CONCLUSIONS: Formaldehyde concentrations of 0.7ppm for 4h and of 0.4ppm for 4h with peaks of 0.8ppm for 15min did not cause adverse effects related to irritation, and no differences between hypo- and hypersensitive subjects were observed.

Onyije, FM and OG Avwioro[2012[Excruciating effect of formaldehyde exposure to students in gross anatomy dissection laboratory[BACKGROUND: Formaldehyde is extensively used for preservation of cadavers in departments of anatomy. However, it is a noxious chemical which may cause serious health problems.

OBJECTIVE: To assess the effect of exposure of medical students to formaldehyde at the Department of Anatomy, Niger Delta University, Nigeria.

METHODS: In a questionnaire-based study, 93 second-year medical students were surveyed at the Department of Human Anatomy, Niger Delta University, Nigeria. The average duration of exposure for each student in the dissection hall was 6 hr/wk. Participants with history of cough, respiratory or skin diseases were excluded from the study.

RESULTS: Out of 93 questionnaires distributed, 75 were completed and returned (response rate: 81%). Of 75 students, 58 (77%) were strongly affected by unpleasant smell of formaldehyde. It was followed by "runny or congested nose" and "redness of the eyes." "Skin-related diseases" was identified as the least ranked effect of formaldehyde.

CONCLUSION: Due to the numerous health challenges that formaldehyde causes to students in the gross anatomy dissection laboratories, it cannot be considered as a suitable chemical for embalmment of cadaver for dissection.

Roda, C, C Guihenneuc-Jouyaux, et al[2013[Environmental triggers of nocturnal dry cough in infancy: New insights about chronic domestic exposure to formaldehyde in the PARIS birth cohort[Although formaldehyde is a common indoor pollutant, its impact on respiratory symptoms in childhood remains unclear. The aim of this study was to examine the relation between domestic formaldehyde exposure and occurrence of coughing, one of the most prevalent respiratory symptoms during the first year of life of infants from the PARIS birth cohort involving 3840 healthy full-term babies. The presence of respiratory symptoms, including dry cough at night apart from a cold or chest infection in the past 12 months was reported on a standardized health questionnaire. Formaldehyde exposure was estimated for all infants using a predictive model established from data (both repeated measurements and information about determinants of levels) collected in a random sample of infants from the cohort. An unconditional logistic regression was fitted to study the relation between annual domestic formaldehyde exposure and dry cough at night, adjusting for all potential risk factors/confounders. The prevalence of dry cough at night was 14.9%. Parental history of allergy was found to modify the relation between environmental factors and dry cough. Cockroaches, used mattresses, and family stressor events were associated with dry cough in infants with parental allergy history. Conversely, domestic formaldehyde exposure tended to increase occurrence of dry cough at night only among babies without parental history of allergy (adjusted OR per 10 µg/m(3) increase in levels, single imputation approach: 1.45, 95% CI: 1.08-1.96, and Bayesian approach: 1.12, 0.91-1.36). This study suggests that the impact of indoor environmental exposure on dry cough at night in infancy is different depending on the presence or not of parental history of allergy.

Sauer, UG, S Vogel, et al[2013[In vivo-in vitro comparison of acute respiratory tract toxicity using human 3D airway epithelial models and human A549 and murine 3T3 monolayer cell systems[

Shapiro, D, CE Deering-Rice, et al[2013[Activation of transient receptor potential ankyrin-1 (TRPA1) in lung cells by wood smoke particulate material[Cigarette smoke, diesel exhaust, and other combustion-derived particles activate the calcium channel transient receptor potential ankyrin-1 (TRPA1), causing irritation and inflammation in the respiratory tract. It was hypothesized that wood smoke particulate and select chemical constituents thereof would also activate TRPA1 in lung cells, potentially explaining the adverse effects of wood and other forms of biomass smoke on the respiratory system. TRPA1 activation was assessed using calcium imaging assays in TRPA1-overexpressing HEK-293 cells, mouse primary trigeminal neurons, and human adenocarcinoma (A549) lung cells. Particles from pine and mesquite smoke were less potent agonists of TRPA1 than an equivalent mass concentration of an ethanol extract of diesel exhaust particles; pine particles were comparable in potency to cigarette smoke condensate, and mesquite particles were the least potent. The fine particulate (PM < 2.5 µm) of wood smoke were the most potent TRPA1 agonists and several chemical constituents of wood smoke particulate, 3,5-ditert-butylphenol, coniferaldehyde, formaldehyde, perinaphthenone, agathic acid, and isocupressic acid, were TRPA1 agonists. Pine particulate activated TRPA1 in mouse trigeminal neurons and A549 cells in a concentration-dependent manner, which was inhibited by the TRPA1 antagonist HC-030031. TRPA1 activation by wood smoke particles occurred through the electrophile/oxidant-sensing domain (i.e., C621/C641/C665/K710), based on the inhibition of cellular responses when the particles were pretreated with glutathione; a role for the menthol-binding site of TRPA1 (S873/T874) was demonstrated for 3,5-ditert-butylphenol. This study demonstrated that TRPA1 is a molecular sensor for wood

smoke particulate and several chemical constituents thereof, in sensory neurons and A549 cells, suggesting that TRPA1 may mediate some of the adverse effects of wood smoke in humans.

Spanel, P, K Dryahina, et al[2013[A quantitative study of the influence of inhaled compounds on their concentrations in exhaled breath[Throughout the development of breath analysis research, there has been interest in how the concentrations of trace compounds in exhaled breath are related to their concentrations in the ambient inhaled air. In considering this, Phillips introduced the concept of 'alveolar gradient' and judged that the measured exhaled concentrations of volatile organic compounds should be diminished by an amount equal to their concentrations in the inhaled ambient air. The objective of the work described in this paper was to investigate this relationship quantitatively. Thus, experiments have been carried out in which inhaled air was polluted by seven compounds of interest in breath research, as given below, and exhaled breath has been analysed by SIFT-MS as the concentrations of these compounds in the inhaled air were reduced. The interesting result obtained is that all the exogenous compounds are partially retained in the exhaled breath and there are close linear relationships between the exhaled and inhaled air concentrations for all seven compounds. Thus, retention coefficients, a, have been derived for the following compounds: pentane, 0.76 0.09; isoprene, 0.66 0.04; acetone, 0.17 0.03; ammonia, 0.70 0.13, methanol, 0.29 0.02; formaldehyde, 0.06 0.03; deuterated water (HDO), 0.09 0.02. From these data, correction to breath analyses for inhaled concentration can be described by coefficients specific to each compound, which can be close to 1 for hydrocarbons, as applied by Phillips, or around 0.1, meaning that inhaled concentrations of such compounds can essentially be neglected. A further deduction from the experimental data is that under conditions of the inhalation of clean air, the measured exhaled breath concentrations of those compounds should be increased by a factor of 1/(1-a) to correspond to gaseous equilibrium with the compounds dissolved in the mixed venous blood entering the alveoli. Thus, for isoprene, this is a factor of 3, which we have confirmed experimentally by re-breathing experiments.

Starr, TB and JA Swenberg[2013[A novel bottom-up approach to bounding low-dose human cancer risks from chemical exposures[We propose a novel bottom-up approach to the bounding of low-dose human cancer risks from chemical exposures that does not rely at all upon high-dose data for human or animal cancers. This approach can thus be used to provide an independent "reality check" on low-dose risk estimates derived with dose-response models that are fit to high-dose cancer data. The approach (1) is consistent with the "additivity to background" concept, (2) yields central and upper-bound risk estimates that are linear at all doses, and (3) requires only information regarding background risk, background (endogenous) exposure, and the additional exogenous exposure of interest in order to be implemented. After describing the details of this bottom-up approach, we illustrate its application using formaldehyde as an example. Results indicate that recent top-down risk extrapolations from occupational cohort mortality data for workers exposed to formaldehyde are overly conservative by substantial margins.

Ulker, OC, I Ates, et al[Evaluation of non-radioactive endpoints of ex vivo local lymph node assay-BrdU to investigate select contact sensitizers[The present study sought to verify the utility of the non-radioactive endpoints LLNA BrdU (5-bromo-2'-deoxyuridine) ex vivo incorporation and cytokine release using auricular lymph node cells isolated from BALB/c mice topically treated with a strong (formaldehyde or p-phenylene-diamine [PPD]), moderate sensitizer (cinnamal), or weak sensitizer (eugenol). Stimulation index (SI) and EC(3) values were calculated for each agent. Based on the results of ex vivo LLNA-BrdU assays, EC(3) values were calculated to be 0.29, 0.09, 1.91, and 16.60% for formaldehyde, PPD, cinnamal, and eugenol, respectively. These results were in good agreement with data from previous standard radioactive LLNA. Cytokine analyses indicated T(H)1 and T(H)2 cytokine involvement in the regulation of murine contact allergy and these could be utilized as endpoints in assessments of contact allergy in mice. In conclusion, the current study provided evidence that the non-radioactive endpoint LLNA BrdU ex vivo incorporation could be of use as a viable alternative approach to assess the skin sensitization potential of test compound with respect to improving animal welfare. This is of particular importance in the case of any laboratory where it might be difficult to handle and/or readily employ radioisotopes. Further studies will be required to confirm-across test agents-the reproducibility as well as the limits of utility of this new ex vivo BrdU method.

Wang, F, an, C Li, et al[2012[Oxidative Stress Levels of Kunming Mice Following Short-Term Exposure to Volatile Organic Compounds (VOCs) Mixture[